A Topological Phase Approach to Optimisation of 2D Photonic Crystal Geometries

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Singular optics, involving the study of topological phase, discontinuities, and defects has recently attracted much interest, e.g. [1]. Such concepts, where light propagation is controlled by geometric considerations, can also be applied to the study of photonic crystals (PC's), in particular to line-defect waveguides [2]. For example, it is well known that the design of an efficient 50/50 'Y'-coupler in a 2D PC is beset by problems such as back reflection, diffractive radiation, and unequal power splitting. Non-deterministic optimisation [3] of the 'Y'-coupler geometry has been successfully performed, but a clear theoretical understanding of the underlying mechanism for optimum light localisation is currently absent. It is the centre point of a 'Y'-coupler that represents a symmetry-breaking phase singularity (i.e. the location of a topological bifurcation) so making light behaviour less predictable. In order to maintain appropriate power and momentum conservation symmetries, couplers require a 'hidden' fourth arm, i.e. an 'X'-geometry, as is well-known in microwave technology with the "magic-T" device. Hence, the topological properties of PC geometries require careful design to exploit their full potential.

[1] M.V. Berry and C. Upstill, *Prog. Opt, XVII*, p.257-346 (1980).
[2] E. Rochat, M.C. Parker, S.D. Walker, *ECOC'04*, We4.P.045, Stockholm (2004)
[3] S. Chakraborty, M.C. Parker, *et al.*, *ECOC'04*, We4.P.050, Stockholm (2004)